METHOD AND APPARATUS FOR APPLYING LIQUID COMPOSITIONS IN RAIL SYSTEMS

FIELD OF INVENTION

[0001] The present invention relates to liquid composition application systems used in rail systems.

BACKGROUND OF THE INVENTION

[0002] The control of friction and wear of metal mechanical components that are in sliding or rolling-sliding contact is of great importance in the design and operation of many machines and mechanical systems. For example, many steel-rail and steel-wheel transportation systems including freight, passenger and mass transit systems suffer from the emission of high noise levels and extensive wear of mechanical components such as wheels, rails and other rail components. The origin of such noise emission, and the wear of mechanical components may be directly attributed to a number of factors: wheel and rail interaction characteristics; operating conditions including curvature, speed; and rail material strength including hardness.

[0003] Mechanical friction at the wheel-rail interaction includes: a) friction on both tangent and curved tracks due to rolling friction on the horizontal interface between wheel and rail and b) curve resistance is the additional resistance in curves due to increased lateral friction forces in curves. The sum of the two effects usually accounts for about 5 to 10% of a train's energy consumption in passenger trains and up to 30% very heavy freight trains.

[0004] In a dynamic system wherein a wheel rolls on a rail, there is a constantly moving zone of contact. For purposes of discussion and analysis, it is convenient to treat the zone of contact as stationary while the rail and wheel move through the zone of contact. When the wheel moves through the zone of contact in exactly the same direction as the rail, the wheel is in an optimum state of rolling contact over the rail. However, because the wheel and the rail are profiled, often misaligned and subject to motions other than strict rolling, the respective velocities at which the wheel and the rail move through the zone of contact are not always the same on a tangent section of the railway, causing sliding movement between the wheel and the rail. The sliding

movement is more pronounced when fixed-axle railcars negotiate curves wherein true rolling contact can only be maintained on both rails if the inner and the outer wheels rotate at different peripheral speeds. This is not possible on fixed-axle railcars. Thus, under such conditions, the wheels undergo a combined rolling and sliding movement relative to the rails. Sliding movement may also arise when traction is lost on inclines thereby causing the driving wheels to slip. In addition, when the when railcars pass through a curvature, the centripetal force will cause additional friction between the flanges of the profiled railcar wheel and the inside side of the 'high rail' of the curvature.

[0005] Hence, the requirement for reduction in sliding movement between the railcar wheels and the rail is different between tangent sections and curvature of a railway, between incline and decline of a railway, and a combination thereof.

[0006] The magnitude of the sliding movement is roughly dependent on the difference, expressed as a percentage, between the rail and wheel velocities at the point of contact. This percentage difference is termed creepage.

[0007] At creepage levels larger than about 1%, appreciable frictional forces are generated due to sliding, and these frictional forces result in noise and wear of components (H. Harrison, T. McCanney and J. Cotter (2000), Recent Developments in COF Measurements at the Rail/Wheel Interface, Proceedings The 5th International Conference on Contact Mechanics and Wear of Rail/Wheel Systems CM 2000 (SEIKEN Symposium No. 27), pp. 30 - 34, which is incorporated herein by reference). The noise emission is a result of a negative friction characteristic that is present between the wheel and the rail system. A negative friction characteristic is one wherein friction between the wheel and rail generally decreases as the creepage of the system increases in the region where the creep curve is saturated. Theoretically, noise and wear levels on wheel-rail systems may be reduced or eliminated by making the mechanical system very rigid, reducing the frictional forces between moving components to very low levels or by changing the friction characteristic from a negative to a positive one, that is by increasing friction between the rail and wheel in the region where the creep curve is saturated. Unfortunately, it is often impossible to impart greater rigidity to a mechanical system, such as in the case of a wheel and rail systems used by most trains. Alternatively, reducing the frictional forces between the

wheel and the rail may greatly hamper adhesion and braking and is not always suitable for rail applications. In many situations, imparting a positive frictional characteristic between the wheel and rail is effective in reducing noise levels and wear of components.

[0008] In recent years, significant advancements in lubricant technology have led to the production of special rail lubricants containing friction modifiers that produce "positive friction characteristics" wherein the coefficient of friction increases with the speed of sliding. For example, US 6,135,767 (which is incorporated herein by reference) describes friction modifiers with high or very high positive coefficients of friction; US 2004 0 038 831 A1 (which is incorporated herein by reference) describes a high positive friction control composition with a rheological control agent, a lubricant, a friction modifier, and one, or more than one of a retentivity agent, an antioxidant, a consistency modifier, and a freezing point depressant; and WO 02/26919 (US 2003 0 195 123 Al; which is incorporated herein by reference) describes a liquid friction control composition with enhanced retentivity with an anti-oxidant. The liquid friction control composition may also comprise other components such as a retentivity agent, a rheological control agent, a friction modifier, a lubricant, a wetting agent, a consistency modifier, and a preservative. These friction modifiers are typically solid powders or fine particulates that are suspended in relatively thick fluids. These solid materials enhance friction between a wheel and the rail to promote rolling engagement rather than sliding.

[0009] With the development of these new compositions, there is a need for lubricant delivery systems that can accurately and precisely apply such lubricants to the rail. Prior art devices for application of the lubricant or friction modifiers can be classified into two categories: stationary devices on the wayside; and devices mounted on a vehicle.

[0010] Stationary devices are usually deployed immediately preceding a location where application is required, the movement of the train tends to move the liquid composition into the area so as to modify the friction on the rail sections and wheel flanges as the train passes. There have been several designs of stationary devices, and apparatus for securing them so as to permit the automatic application of an appropriate composition to the rail when a train passes. In some of these devices, it is

the depression of the roadbed that triggers the dispensation of a composition; in others, it is the tripping of a mechanical device, such as a lever or a plunger, by the train's wheels that activates a composition dispensing mechanism. Example of such prior art devices is shown in U.S. 5,641,037. These prior art devices are often mechanically complex and difficult to install and maintain in the field.

[001 1] Mobile liquid composition delivery devices for lubricating rails, such as the one described in US 5,992,568, may be mounted on a track vehicle, such as a pickup truck (Hi Rail system) equipped with additional flanged wheels.

[0012] US 6,578,669 describes a liquid delivery system mounted on a railroad locomotive for applying to a composition to a rail. The system comprises a lubricant path, a reservoir for holding the lubricant, a pump to convey the lubricant along the lubricant path, and a dispensing nozzle mounted to the locomotive above each rail for directing the lubricant onto each rail. However, as drive wheels require good contact with the rail surface, slippage will occur if lubricant is applied in front of any of the drive wheels, and this must be avoided. As locomotives can move in both directions, the delivery system mounted on a locomotive can only be used in an orientation where the active nozzle is behind the driving wheels of the locomotive and this contributes to the complexity of the mechanical systems that already exist on a locomotive. When several locomotives are used in series for pulling heavy freight trains, the nozzle needs to be located behind all driving wheels of the locomotives. The addition or removal of locomotives during use increases the complexity of determining the location of the delivery system within a locomotive consist. Furthermore, a locomotive has limited space for accommodating a liquid reservoir, pump, and delivery systems for applying a liquid composition to a rail system.

[0013] Application of liquid compositions within a rail system maybe location dependent, so that a certain liquid compositions may be applied at a certain location of the rail system, applied in different amount at different locations of rail, or different combinations of friction modifiers or friction modifiers and lubricants may be used at different locations of the rail, for example, applied to the top of the rail, or along a side surface of the head of the rail.

[0014] Global position system (GPS) has been widely used for locating position on earth. It is well known in the art that navigation systems have been developed, for roadway type vehicles which use a GPS system for determining the approximate location of the vehicle in relation to a street database. By relating the approximate location of the vehicle with information concerning its direction of travel, it is sometimes possible to locate the vehicle on the database

SUMMARY OF THE INVENTION

[0015] The present invention relates to liquid composition application systems used in rail systems.

[0016] It is an object of the invention to provide a novel method and apparatus for applying liquid compositions in rail systems.

[0017] The present invention provides a method (A) for applying a liquid composition to a rail surface comprising,

i. supplying the liquid composition in one or more than one reservoir on a rail car; and

ii. applying the liquid composition from the one or more than one reservoir to the rail.

Furthermore, after the step of supplying (step i), there may be a step of:

a. determining a change in the topology of the rail within a rail system,

and, in the step of applying (step ii), the liquid composition is applied to the rail as a result of a change in the topology of the rail. The rail car may be a freight car or a passenger car.

[0018] The present invention pertains to the method (A) as described above, wherein in the step of applying (step ii), the liquid composition is applied to the top of the rail, the side of the rail, or both the top and the side of the rail.

[0019] The present invention is also directed to the method (A) as described above, further comprising a step of obtaining and processing system information, the system

information comprising topological information, data from a liquid delivery system comprising the one or more than one reservoir, and both topological information and data from a liquid delivery system, wherein the system information is obtained and processed either locally within the rail car, or remotely, at a site location separate from the rail car.

[0020] The present invention also provides a liquid composition application system mounted on a rail car comprising:

i. one or more than one reservoir for holding a liquid composition;

ii. a pipe connected to the one or more than one reservoir; and

iii. a pump, in fluid communication with the pipe, for moving the liquid composition from the one or more than one reservoir to one or more than one dispensing nozzle.

[0021] Furthermore, the liquid composition application system may comprise a controller, or a metering device, for controlling operation of the pump. The controller may be a microprocessor. The controller may be connected to a locomotive control circuit, and respond thereto, or the controller may be located on a rail car and accessed remotely from a location separate from the rail car.

[0022] The present invention provides a liquid composition application system as defined above further comprising a source of pressurized air connected to the one or more than one dispensing nozzle to dispense the liquid composition as an atomized spray.

[0023] The present invention also pertains to a rail car, comprising a liquid composition application system, the liquid composition application system comprising:

i. one or more than one reservoir for holding a liquid composition;

ii. a pipe connected to the one or more than one reservoir; and

iii. a pump, in fluid communication with the pipe, for moving the liquid composition from the one or more than one reservoir to one or more than one dispensing nozzle.

[0024] The present invention provides a method (B) for applying a liquid composition in a railway system comprising:

i. supplying the liquid composition in one or more than one reservoir on board a train consist;

ii. receiving topological information from a topological device on board the train consist;

iii. processing the topological information received from the topological device using a processing device to produce processed topological information; and

iv. applying the liquid composition from one car within the train consist to a rail surface within the rail system according to the processed topological information.

In the step of processing (step iii), the processing device may be a computer, a microprocessor, or a programmable logic circuit, furthermore, the one car within the train consist may be a locomotive or a rail car.

[0025] The present invention pertains to a method (B) according just defined, wherein in the step of receiving (step i), the device further comprises a global positioning system (GPS), the GPS providing real-time topological information to the device for controlling the application of the liquid composition to the rail surface. The device may further comprises a database having topology information of the railway system, and wherein the device coordinates the information from the GPS with the database information for controlling the application of the liquid composition to the rail surface. Alternatively, in the step of receiving (step i), the device may further comprise a wheel speed monitor for determining differential speed of a pair of wheels located on opposite side of the car within the train consist; where a difference in the wheel speed is used to determine curvature in the rail system, and control the application of the liquid composition to the rail surface. In the step of receiving (step

i), the device may also comprise a rail-width detection system, for example a camera-based rail-width detection system, or one or more than one proximity probe.

[0026] The present invention also pertains to the method (B) defined above, wherein in the step of receiving (step i), one car in the train consist comprises a gyroscopic device for determining topology information of the railway system; the gyroscopic device providing topological information to the device for controlling the application of the liquid composition to the rail surface.

[0027] The present invention provides a device for applying a liquid composition to a rail surface, comprising:

i. means for acquiring topological information in real-time;

ii. means for applying the liquid composition to the rail surface; and

iii. a processing device for receiving the topological information, and controlling the application of the liquid composition.

Preferably, the means for acquiring is selected from the group consisting of a global position system (GPS), a device for determining the speed of a pair of wheels, one or more than one proximity probe, and one or more than one gyroscope.

[0028] An advantage of placing the liquid composition application system in a rail car is that the reservoir capacity may be increased from that available in a locomotive, yet space in the rail car is impacted to minimal degree and the carrying capacity of the rail car may still carry an appreciable revenue generating load. Furthermore, by having the application system located in a rail car, locomotives may be added, removed, or their relative position with respect to each other changed without the need to consider the location of the application of the liquid composition to the rail as in most cases it will be behind all of the drive wheels of the locomotive. In the case of a distributed power, when an additional locomotive is placed within the train consist, it is preferred that the rail car comprising the application system is placed behind the additional locomotive. However, placement of the rail car comprising the application system ahead of the additional locomotive is acceptable, provided that there are a sufficient

number of axel-passes, for example more than 8 or so axel passes to help dry out the applied composition.

[0029] An additional advantage with the liquid composition application system of the present invention is that configuration of the rail system need not be known, yet with the use of a GPS, the inclination or curvature of track may be readily detected and the application of the liquid composition altered accordingly.

[0030] This summary of the invention does not necessarily describe all features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[003 1] These and other features of the invention will become more apparent from the following description in which reference is made to the appended drawings wherein:

[0032] FIGURE 1 shows a prior art liquid composition application system;

[0033] FIGURE 2 shows a side view of an example of a liquid composition application system mounted in a rail car according to an aspect of the present invention;

[0034] FIGURE 3 shows a top view of an example of a liquid composition application system as illustrated in Figure 2;

[0035] FIGURE 4 shows a side view of an example of a liquid composition application system as illustrated in Figure 2 (viewed from the end of the rail car);

[0036] FIGURE 5 shows a end view of an example of circulation equipment (160) mounted on the side of the reservoir (120) as illustrated in Figure 4 (viewed from the side of the rail car);

[0037] FIGURE 6 shows a end view of an example of main electrical equipment (150) and circulation equipment (160), mounted on the side of the reservoir as illustrated in Figure 4 (viewed from the side of the rail car);

[0038] FIGURE 7 shows an end view of an example of a reservoir of the liquid composition application system as illustrated in Figure 4(viewed from the side of the rail car);

[0039] FIGURE 8 shows a cross sectional view of an example of a reservoir as illustrated in Figure 4;

[0040] FIGURE 9 shows a side view of a rail wheel assembly showing an example of a way of attaching a nozzle assembly to the side frame (140);

[0041] FIGURE 10 shows a front view of a rail wheel assembly illustrated in Figure 9;

[0042] FIGURE 11 shows a top view of a rail wheel assembly illustrated in Figure 9;

[0043] FIGURE 12 shows a schematic of a train consist passing through a rail with a curvature;

[0044] FIGURE 13 shows a block diagram of an example of a control system for applying a liquid composition

[0045] FIGURE 14 shows tank level data indicating utilization of liquid composition by a rail car fitted with a liquid composition application system as described herein.

DETAILED DESCRIPTION

[0046] The present invention relates to liquid composition application systems used in rail systems.

[0047] The following description is of a preferred embodiment.

[0048] In railway industry, especially for the transport of freights, one or more locomotives can be physically connected together, with one locomotive designated as a lead locomotive and the others as trailing locomotives, this is usually called a 'locomotive consist'. A 'train' or a 'train consist' means a combination of revenue generating cars (RGC; also called rail cars), and a locomotive consist. A rail car can be a passenger car or a freight car for example, but not limited to, a flat bed car, a refrigerated car, a bulk materials car for example an ore car, a chemical car, a seed or

agricultural materials car, or a box car. Freight cars may unload by tipping. A common characteristic of a rail car is that it is not self-propelled. In contrast, a locomotive, or a mobile liquid composition delivery device such as the one described in US 5,992,968 (a Hi Rail system), are self-propelled.

[0049] Figure 1 shows a prior art composition delivery system (US 6,578,669) mounted on a railroad locomotive for applying a liquid composition to a rail. A single locomotive (10) is attached to rail car (12). A delivery system (20), mounted in locomotive (10) comprises a metering and a dispensing system (60), comprised of individual dispensing assemblies (6OC and 60D), a tank (32) for storing a liquid composition, and a delivery path (44) to convey the composition from the tank (32) to the nozzles (34 and 82). Piping system (44) includes a section that extends into the tank (32), and a pump (38) that is operatively disposed within piping section (44). A dispensing conduit extends from housing (62) to a dispensing nozzle (82). Operative components for metering and dispensing the composition are disposed within a watertight housing (62).

[0050] The present invention provides a method for applying a liquid composition to a rail surface comprising, supplying the liquid composition in one or more than one reservoir on a rail car (revenue generating car), and applying the liquid composition from the one or more than one reservoir to the rail surface. The liquid composition may be applied to any section of rail, for example, a curved section of rail, a tangent (straight) section of rail, or both a curved and tangent section of rail. Furthermore, the supply, and the regulation of the supply of the liquid composition may be self-contained within the rail car. In this manner there is no need to have the rail car in communication with the locomotive for the liquid composition to be applied to the rail surface. Rather, the supply, and regulation of the supply, of the liquid composition of the rail car may operate independently from the locomotive. By having the liquid reservoir and control of the reservoir self-contained within the rail car, the rail car may be used within any train consist without requiring additional wiring to the locomotive. This ensures ease of adapting the revenue generating car comprising the liquid composition and reservoir, to any train system.

[0051] With reference to Figures 2-1 1, there is shown an example of a liquid composition delivery system (100) as part of a rail car (1 10). The example shown in

Figure 2, which is not to be considered limiting, is that of an ore car. The delivery system has a liquid composition reservoir (120) for storing a liquid composition that is to be applied to the rail. This reservoir may comprise one or more than one compartment, depending upon whether one or more than one liquid composition is to be applied to the rail. One or more than one nozzle assembly (220, see Figures 9-1 1) may be attached to the rail car for example at a side frame (140) between the railcar wheels (130; Figures 9-1 1). It is preferred that at least two nozzle assemblies are mounted on a rail car, one assembly on each side of the rail car in order to deliver the composition to one track, or both tracks track of the rail system. Each nozzle assembly may comprise one or more than one nozzle, depending upon whether the top of the rail, the side of the head of the rail (gauge face), or both are to be treated with a composition.

[0052] The delivery system (100) may comprise a plurality of metering and a dispensing systems (160, Figures 3 and 6), for example one or two metering and a dispensing systems, a circulation pump (164, Figure 4) to mix, circulate and refresh the composition through the lines of a pipe system (163) that extend from the reservoir to the metering and dispensing system. The circulation pump may also maintains pressure with the pipe system, which is typically a closed loop pipe system, made from any suitable material for example but not limited to a polymeric material, stainless steel, or the like. The circulation pump (164) also conveys the liquid composition from the reservoir (120), through a filter (168), to a supply line (158) entering one or both of the metering and dispensing systems (160). The circulation pump may be fitted with differential pressure switches that can shut off the pump in the event that the filter becomes clogged. Delivery of the composition from the pipe system (163) to the supply line (158) may be regulated by one or more than one value, for example a solenoid valve. Each dispensing system may include a metering pump (located within dispensing system 150) that delivers the liquid composition received from the pipe system (163), via a supply line (e.g. 158), to one or more than one nozzle assembly (220; Figures 9-1 1)) via a delivery path (e.g. 166; Figures 5, 6 and 9). The dispensing system may also be fitted with solenoid valves and pressure switches to open, close, and regulate the flow of the composition. One metering and dispensing system may be used to supply both of the nozzles on either sides of the rail

car, or two dispensing systems (160) may be used as shown in Figures 5 and 6, each one independently supplying liquid composition to the nozzle assembly (220).

[0053] Electrical components involved in regulating and monitoring delivery of the liquid composition are placed within a protected housing (150), for example at one end of the reservoir (120). The electrical components may include but are not limited to one or more than one microprocessor, programmable logic controller, or computer, that receive information about the rail system during train consist travel, in order to regulate liquid composition delivery to the rail system. Preferably, there is an operator-actuated interface, for example a touch screen, or a radio frequency transceiver that permits remote access to the data and information gathered from the rail car, and that permits implementing operating criteria as required. The electrical components of the control system may carry out, but are not limited to the following determinations:

-processing changes in topological information in the rail system, for example using a GPS or other rail topological sensing systems as described herein;

- controlling the dispensing system as required using information obtained from evaluation of rail topological data, for example but not limited to, orientation of the rail car, speed of the rail car, curve sensing, severity of curve, changes in elevation, or temperature, to regulate composition delivery to one or both of the tracks, to the top or gauge-face of the rail, or both;

- monitoring pressure, temperature, valve status, pump status and other circulation parameters within the reservoir, pipe system, supply lines, circulation pump, metering pump(s), filter(s), and nozzle assemblies;

-controlling the heating system as required within the reservoir, pipe system, supply lines, circulation pump, metering pump(s), filter(s), and nozzel assemblies;

- regulating the metering pump output with respect to rail car speed, to ensure a consistent amount of the fluid composition is applied to the railhead;

- monitoring tank level and controlling dispensation of the fluid composition. For example if a low tank level switch is activated, shuts down fluid dispensation if high pressure is detected in the dispensing system, switches off the fluid dispensation if a specific drop in brake pipe pressure is determined, or if atomizing air pressure is lost. Furthermore, monitoring tank levels provides an indicator that the fluid composition is being applied to the rail surface;

- shutting of the delivery system below a threshold rail car speed, for example below about 5 to about 10 mph, or more preferably, below about 7 mph;

- determining the orientation of the rail car within respect to the train consist. This ensures that the liquid composition is delivered to the nozzle assembly on the desired side of the rail car, for example when applying to curved track; and

- a combination of the above.

[0054] Orientation of the rail car within a train consist may be required if rail cars are rotated within the train consist, for example to equalize wheel wear. Rail car orientation may be determined using any system that can determine if one (e.g. the A) or the other end (B) of the rail car is facing forward within the train consist. Non limiting examples for determining orientation of a rail car include the use of infrared, laser or other light beams and corresponding sensors to determine beam reflection or interruption and using this signal to interpret which end of the rail car, A or B, is facing forward, or the use of electrical circuit monitoring devices, so that when the rail is linked to a power source of a leading car or locomotive, the detection of current indicates which end, the A or B end, is attached to the power source. An example of an electrical current monitoring device includes, but is not limited to, the use of an eddy current device, for example a current transformer (current transducer). One current monitoring device is mounted at the A end, the other at the B end of the rail car. This device generates an electrical signal when linked to the power source of the preceding car or locomotive. As only one end of the rail car is linked to the power source, for example the A end, the resulting signal may be used to determine which end of the rail car is forward.

[0055] Figure 3 is a non-limiting top view of a delivery system (100) mounted on a freight car. Circulation equipment (160) and electrical equipment (150) may be

mounted on one or both sides of the reservoir (120). The system (100), including the reservoir (120), metering and dispensing equipment (160), and control (electrical) system (150), is preferably covered to protect it from payload material as well as debris that can potentially impact on the performance of the equipment. The components of the delivery system (100) may be attached to the frame of the rail car, or attached to the bed of container that is attached to the frame of the car (for example see frame supports 185, Figures 4, 7 and 8).

[0056] The delivery system of the present invention is also able to withstand tipping of the freight car through an angle from about 90° to about 165° or any angle therebetween, for example, when the payload is being discharged from the rail car.

[0057] A non-limiting side view of a reservoir (120) is shown in Figure 4, and non-limiting end views of the circulation and electrical equipment housing (150, 160, respectively) are shown in Figures 5 and 6. The reservoir (120) may have a working capacity of about 50 to about 500 US gallons (about 200 to about 2000 liters), depending upon the space available. Preferable, the volume of the reservoir is from about 100 to about 300 gallons (about 400 to about 1200 liters), more preferably about 200 gallons (about 750 liters). The reservoir is fitted with inlet and outlet ports to allow transfer of fluid from the reservoir to the circulation pump (164) and back as required. The reservoir is also preferably fitted with baffles (124) to reduce movement of the liquid composition within the reservoir, and stiffeners (182). The reservoir may be enclosed in a frame (180; Figure 7) and insulated to retain heat as required. The reservoir (120) may be fitted with a pressure relief valve (126), a vacuum break (128), a liquid volume-indicating device for example a mechanical float valve (122), a series of level switches to monitor fluid level, or both, and a temperature switch.

[0058] To maintain an appropriate temperature of the composition within the delivery system when used in cold climates, the reservoir (120) may be outfitted with one or more than one heat blanket, located on the bottom of the reservoir, for example but not limited to silicone rubber heat blankets, and the reservoir may be insulated. Dispensing lines, including the pipe system (163), supply lines (158) delivery lines (166) and nozzle assemblies (220) may also be heat traced and insulated as required. Main electrical enclosures (e.g. 150), and the dispensing and metering system (160)

may contain radiant heat sources and they may be insulated to prevent heat loss. The heating system may be controlled by a temperature sensor. The temperature sensor activates the heating system when ambient temperature drops below a certain preset temperature. Additionally, the heating system may be monitored and actuated remotely.

[0059] Referring to figures 9 to 11, a nozzle assembly (220) is mounted to the rail car is any suitable manner that positions the nozzle assembly in a position close to the top of the rail track. For example which is not to be considered limiting, the nozzle assembly (220) may be mounted to a frame (140) via a bracket (e.g. 200). The nozzle assembly may comprise one or more than one nozzle as required. The examples in Figures 9-1 1 show a nozzle assembly comprising one nozzle. However, additional nozzles may be present in the nozzle assembly if the top and the side of the railhead (gauge face of rail) are to receive the same or different liquid composition. A nozzle such as that described in WO 03/099449 (which is incorporated herein by reference) may be used. The distance between nozzle and top of the rail is preferably between about 0.5 and about 5 inches (about 10 to about 80 cm), more preferably, from about 2 to about 4 inches (about 30 to about 60 cm). Adjustable brackets may be used to, for example, compensate for differences in wheel diameters in different rail cars, or due to decrease diameters resulting from wear.

[0060] To maintain elevated temperature during use in low temperature environments, the nozzle dispensing enclosures may contain radiant heat sources or cartridge heaters. The dispensing nozzle enclosures may also be insulated to prevent heat loss, for example using a sprayable air cured polyurethane foam or sheet polystyrene. The heating system of the nozzle may be controlled by a temperature sensor that is activated when ambient temperature drops below a certain preset temperature. Furthermore, heating system of the nozzle may be controlled by a temperature sensor that is activated remotely.

[0061] The liquid composition is transported from the reservoir (12) to the nozzle assembly (220) by a metering pump housed within one or more than one dispensing and metering system (160). The dispensing system may comprise one or more than one pump, for example a pump for each side of the rail car as shown in Figures 5 and 6. Fluid supply to the one or more than one pump can be controlled by an electrically

actuated solenoid valve. Pump speed can further be correlated to car speed in order that the same amount of fluid is applied to the railhead. Furthermore, pump speed may be monitored and regulated remotely.

[0062] The application of the liquid composition is preferably in the form of atomized spray by using pressurized air that can be supplied by the locomotive to either end of the rail car, or a compressor on board of the rail car. The air pressure may be for example, which is not to be considered limiting, from about 40 to about 80 psi, and remains constant regardless of car speed. The air pressure may be turned on and off using one or more than one electrically actuated solenoid valve. The solenoid valves and air pressure may be monitored and adjusted remotely if desired. The liquid can also be applied through a pump without the use of pressurized air. However, it is also to be understood that other methods of applying the liquid composition to the surface of the rail may be used as many sets of non-driving wheels will pass over the film, and the need for film quality and drying time is not a critical variable.

[0063] Power for the dispensing equipment can be derived from a locomotive, and provided to the rail car from either end of the car. Alternatively, power can also be generated from a generator located onboard the rail car, or from a generator driven from the wheels of the rail car.

[0064] Any liquid composition that can be pumped from the reservoir to a nozzle may be applied using the system of the present invention. Non-limiting examples of liquid compositions that may be applied include those described in US 6,135,767; US 2004 0 038 831 Al; and WO 02/26919 (US 2003 0 195 123 Al; which are incorporated herein by reference).

[0065] Therefore, the present invention also provides a liquid composition application system mounted on a rail car comprising:

i. one or more than one reservoir for holding a liquid composition;

ii. a pipe connected to the one or more than one reservoir; and

iii. a pump, in fluid communication with the pipe, for moving the liquid composition from the one or more than one reservoir to one or more than one dispensing nozzle.

[0066] Furthermore, the present invention pertains to a rail car, comprising a liquid composition application system, the liquid composition application system comprising:

i. one or more than one reservoir for holding a liquid composition;

ii. a pipe connected to the one or more than one reservoir; and

iii. a pump, in fluid communication with the pipe, for moving the liquid composition from the one or more than one reservoir to one or more than one dispensing nozzle.

[0067] In order to ensure that the liquid composition is applied at the appropriate location along the rail system, for example along curved portions of track, a system is required to detect curves, changes in elevation, or other features or location of the track. For example, which is not to be considered limiting, Figure 12A illustrates a railway track with a curvature. Three railway cars (250) are shown as they are traveling at a translation rate "v" through a curved track (230), which has a radius "R". The track curvature C is the reciprocal of the radius R.

[0068] Figure 12B illustrates a pair of railcar wheels (130) on a track in a left-hand turn curvature. The centrifugal force (260; C_f) on a railway car traveling at a speed "v" in a curvature with a radius "R" can be calculated as:

$$C_f = (mv^2)/R,$$

whereby the "m" is the mass of the railway car. The force will cause the profiled wheel flange to contact the inside surface of the outside rail, or the high rail (270; the inside rail is called low rail, 280). The region of maximum wear is indicated as 290. During the movement through a curvature, a train consist may need different amounts or different types of friction modifier to reduce squeal or increase frictional contact with the surface of the rail. Similarly, when a train consist moves through a rail with inclining or declining segment of tracks, or within urban v. rural areas, different

amounts or different types of friction modifier or liquid compositions may also be required.

[0069] In order to regulate, monitor, or both regulate and monitor, the amount and rate of application of a liquid composition on the rail, the delivery system of the present invention may include a control system which has a PLC (programmable logic controller), a microprocessor, or a computer, based system and optionally a GPS (global position system) receiver with antenna, or other curve or elevation detection system. Furthermore, one or more than one transmitting and receiving systems, for example, a radio frequency (RF) transceiver, may also be used to obtain data about the train, rail car, track features, train location, operational parameters of the rail car or the composition delivery system, or a combination thereof, as required. The controller may be located on the railcar and interfaced with the GPS, RF transceiver, operate and collect data locally on the rail car, or a combination thereof. The PLC may be any suitable type, depending upon what system is presently being used with a rail system. Non- limiting examples of suppliers of a PLC include GE, Allen-Bradley (Division of Rockwell Automation), or Siemens. The controller may also be used to detect, transmit, receive or process any required information, for example data regarding whether train is loaded or empty, whether the train is accelerating or braking, temperature, the rate of usage of the liquid composition, or other data relating to the delivery system, for example system pressure and temperature.

[0070] A controller may also be operatively connected to any rail curve, rail elevation, track feature or other detection device, for example to identify whether the train is within an urban or rural area, in a tunnel, on an incline.

[0071] A GPS system (see 300, Figure 13), a radio frequency (RF) transceiver, for example a narrow or broadband RF transceiver (RFT; 300, Figure 13), or both, may be used. The curve, elevation, track feature, or train location, train condition detection system, for example a GPS, RF transceiver, or both, may be located on the rail car, or the locomotive. If located on the locomotive, then the information from the system is operatively linked to the control and delivery system on the rail car. The GPS, RF transceiver, or both, may also be located on the rail car so that the information of the topology, elevation, track features, train features or other data that may be used with the liquid composition delivery system of the present invention may

be operated independently from the locomotive. In this way a suitably outfitted rail car may be used with any train consist and can be readily interchanged between train consists.

[0072] The control system may control the dispensation if a low tank level switch is activated, and shuts down fluid dispensation if high pressure is detected in the dispensing system. The control system may also switch off the fluid dispensation if a specific drop in brake pipe pressure is determined, or if atomizing air pressure is lost. The control system may also modify the rate of application of the liquid to the rail surface. Furthermore, the system will ensure that the fluid composition is not applied to a rail surface below a pre-specified speed, for example the delivery system is shut off below about 5, about 7, or about 10 mph. This avoids application to a rail surface when cars are being shunted in a yard. The control system may be used to limit application of the composition within urban or rural areas if required. The control system may also maintain a minimum level of fluid in the tank for heating purposes and it may shutdown if a low fluid level alarm in the tank is activated. Non-limiting examples of devices that may be used to monitor tank level include ultrasonic sensors, for example a LU12-5001 (MiniMe two wire ultrasonic transmitter, available from Flowline, Los Alamitos CA), or hydrostatic sensors, for example a 3000, 4000, 47000 or 5000series low pressure trasnsducer (available from Gems Sensor, Plainville CT). However, other devices that detect tanks levels directly or indirectly may also be used.

[0073] The control system may have an operator-actuated interface, for example a touch screen, or it may be operated remotely using for example an RF transceiver, for example but not limited to a narrow or broadband transceiver such as a 900Mhz, or other frequency, wireless broadband RF transceiver, or the rail car may be accessed locally and remotely. Information relating to the delivery system within a rail car, the rail car, and other data of interest, may be obtained from the delivery system from a local information panel, touch screen or other similar system, accessed remotely using a suitable transceiver, or both accessed locally at the rail car, or remotely at a location separate from the rail car or train consist, as required. Supervisory reports, alarm history, or summaries of the data may be accessed on a continuous or regular basis, and further detailed reports obtained as required. The following non-limiting

examples outline some of the information flow that may be monitored. However one of skill in the art would understand that other operating data may also be obtained:

Non-limiting examples of Quick Panel Tasks

1. Rail car housing the composition delivery system of the present invention arrives on site and network may be established.

   a. Compile .sum file. This file may be an XML file that will give a Supervisory summary for the trip. This Supervisory summary typically includes:

      i. The car number
      ii. Trip date time of start and finish
      iii. Status of car at finish
      iv. Number of alarms at finish
      v. Tank start level
      vi. Tank End level
      vii. Tank usage for trip

   b. Push .sum file to server.

   c. Push .aim file (xml file containing alarms) to server.

   d. Attempt to push any DAT and DAX files to server (only new files will be pushed, see section on Status Web Service).

2. If information is being accessed remotely, then when a train enters into a good network status area and is connected to network the following process may take place (these may be monitored locally, remotely, or both):

   a. Request from the server, the most recent files that the server has regarding this car.

   b. System's may push any outstanding .sum and .aim files to the server, as required.

c. Systems may also push any outstanding .DAT and .DAX files to the server, if desired.

d. All movements may be logged to any suitable memory medium for example, flash card disk, CD, or other disc, in a desired file format, for example as a text file. Preferably the movements are tagged or dated in some manner.

Non-Limiting example of Server Applications

1. Handle newly arrived files application (handleFiles.exe)

a. Moves any .aim and .sum files into their appropriate directories so they can be viewed from web site.

b. Updates registry with dates of most recent .sum files and .dat files

2. Evaluate .sum files application (evaluate.exe)

a. Accesses .sum files and determines whether an email notification needs to be sent.

b. Configures email destinations (addresses) and determine email delivery to designated sites and for what values

3. Status Web Service (StatusWS)

a. Presents information stored in the registry to the network as a web service.

b. Each rail car will be able to request what information regarding itself the server has.

4. Email notification Service application (Email.exe)

a. A generic console application may be passed an email destination address, a body and a subject. This application sends the appropriate email, and logs it to a text file on the server.

b. This application may be configurable so the Sender and the SMTP server can be changed. These values may also be saved in the server's registry.

5. Web Portal allowing for easy viewing of summaries

    a. A web portal may be created that will give the user access to all summaries (e.g. sorted and grouped by date) as well as all alarm logs.

    b. Each alarm log will represent a period of time, for example, a 24 hour period.

    c. Each summary may represent the amount of time it has taken for a full trip to be made.

    d. All summaries may have hyperlinks to alarm logs that relate to the dates of the trip.

[0074] Topological information of a railway may be acquired or stored in different ways. Figure 13 illustrates a system where the topological information acquired from different sources is used to control the application of liquid composition. One source for acquiring topological information along a rail system is a global positioning system (GPS; 300). In this system, an antenna is mounted at a fixed location, for example at one end, of the rail car. The rail car further comprises a GPS receiver within the electrical equipment (150; Figures 3 and 6). The GPS streams data (for example, conforming to NEMA; National Electrical Manufactures Association) to the PLC including latitude, longitude, speed, heading and altitude. The GPS (300) may provide the rail car speed that can be used to control the dispensing pump application rate, or changes in position of the rail car that can be used to determine whether or not the rail car is negotiating a curved portion of track, or the severity of the curvature of the track, and alter the amounts of liquid composition provides to the surface of the track.

[0075] The information from the GPS (300), RF transceiver (RFT; 300), or both is received by a computer, PLC, or microprocessor (350) which may comprise a database (340) of the topology information about the railway the train consist is traveling, for example, curvature of the track, degrees of track curvature for example mild, medium or sharp curves, whether there are changes in elevation of the track, identify track features, for example, a bridge, a tunnel, switches, urban or rural areas, and the like. Additionally, the car speed or other operational parameters, for example,

but not limited to system pressure, ambient temperature, may also be monitored. The GPS will provide a location of the train consist along the railway and other track features, thereby allowing the computer (350) to control the liquid composition application devices (e.g. 360, 380) independently or together.

[0076] Data obtained about the liquid supply system located on the rail car may be sampled periodically, for example at set times as required, or following the change of state of the parameter. The data being sampled, selected aspects of the sampled data, alarm history, supervisory reports, or a combination thereof, may be stored locally on the rail car on a suitable storage device, for example but not limited to a flash card, CD or disc and accessed as required, or the data being sampled may be delivered to a remote site via the RF transceiver and monitored at this site.

[0077] The GPS system, the RF transceiver, or both, may be located on the rail car, or the locomotive. If located on the locomotive, then the information from the GPS system may be operatively linked to the control and delivery system on the rail car. If located on the rail car the information from the GPS system may be directly used with the control and delivery system on the rail car and the rail car independently monitored from the locomotive.

[0078] With reference to Figure 14, there is shown an example of data for tank levels of a liquid composition application system in a rail car. Such data may be obtained remotely or locally and can be used to monitor consumption levels, application rates, or both of the liquid composition in real time. Additionally, alarms may be recorded to ensure that adequate levels of liquid composition are maintained within the delivery system. The monitoring period may be made for any appropriate duration, for example sampling on continuous, a per-trip, hourly, daily weekly or monthly basis, on a change of state basis, or other desired basis, depending upon use.

[0079] As indicated above, the GPS system may also be used along with an RF transceiver system for monitoring the delivery of the composition along the track, and for remote sensing of the delivery system properties, for example, fluid level within the tank or reservoir, temperature of rail car, track, tank or delivery system nozzle, pressure of the system, the speed of the train and the like.

[0080] The GPS may also calculate the topology information in real-time. For example if the direction of the train consist is changing due to a curve then sampling of GPS data can be used to determine the occurrence of a curve in the track, and the rate of application of the liquid composition to the rail adjusted accordingly. In this case, the computer may instruct one or more than one application devices to apply one or more than one liquid compositions to the gauge face of an outside rail (high rail), to the top surface of the inside rail, or both. Furthermore, different curve severities may also be monitored, for example, mild, medium and sharp curves, and the amount of liquid composition applied to the rail surface may be adjusted accordingly. For example, greater amounts of composition may be applied on sharper curves than on mild curves.

[0081] If the elevation of a train is increasing or decreasing in a given time interval, the train consist may be on an inclining or declining segment of a rail, respectively, and the appropriate dispensation of liquid composition provided to the track. This will ensure that the composition is not being applied to the track during a time when train braking is occurring, for example, going down an incline.

[0082] Similarly, the dispensation of the liquid composition may be modified depending upon the track features encountered by the train and identified by the GPS, for example, a bridge, a tunnel, switches and the like.

[0083] The information of the topology on a railway can also be obtained from a Geographic Information System (GIS). GIS is a system of computer software, hardware and data, to help manipulate, analyze and present information that is tied to a spatial location, usually a geographic location. The topology information of a railway may also include the incline and decline of the rail. Accordingly, the computer may instruct one or more than one application devices to apply one or more than one liquid compositions to the rail.

[0084] Another method of measuring the curvature of a rail is to compare the speed of a pair of wheels on each side of the train (310), if the speed of one wheel is higher than the other, this may indicate a curvature on the railway. In this situation, the computer (350) may instruct for the application of liquid composition for example to

the gauge face on side of the rail car exhibiting the increased wheel speed (the high or outside rail), the low rail (traveling at a lower speed), or both.

[0085] Alternatively, a rail-width detection system, for example but not limited to a camera-based, or laser-based, rail-width detection system, may be employed that can detect changes in the distance between the rails. As a train consist passes through a curve, the distance between the rails increases due to deflection by the outside rail. Any system that can detect this change in inter-rail distance may be employed.

[0086] Another method of measuring the curvature or inclination in a rail system is through the use of a position-sensing device, for example one or more than one gyroscope (320), or proximity probes (330). A gyroscope can measure both the yaw rate and the attitude of a train consist. Proximity probes may detect position shifts within a rail car as the car enters and exists a curve. Therefore, the input from a gyroscope or other position-sensing device can be used to control the liquid composition application devices.

[0087] Other devices (330) may also provide information of the curvature or inclination of the track, for example, operator derived information, for example train speed, orientation of the rail car, or manual inputs relating to curvature, or remotely obtained data about the delivery system of the present invention including levels of the composition within the tank, temperature of the car and track, and this information may then be used by the computer to control the application rate of the liquid composition as required, activate heaters to ensure the tank and nozzle do not freeze, log data about the delivery system in general, application rates, down-load car supervisory reports, logged alarms, and the like.

[0088] Therefore, the present invention provides a method for applying a liquid composition in a railway system, comprising the steps of:

i. supplying the liquid composition in one or more than one reservoir on board a train consist;

ii. receiving topological information from a topological device on board the train consist;

iii. processing the topological information received from the topological device using a processing device to produce processed topological information; and

iv. applying the liquid composition from one car within the train consist to a rail surface within the rail system according to the processed topological information.

[0089] The device may be a computer, PLC or microprocessor, and further comprise a GPS that provides real-time topological information to the device for controlling the application of the liquid composition to the rail surface. A database having topology information of the railway system may also be included within the device, and the device coordinates the information from the GPS with the database information for controlling the application of the liquid composition to the rail surface. Additionally, the device may comprise a wheel speed monitor for determining differential speed of a pair of wheels located on opposite side of a car within the train consist; where a difference in the wheel speed is used to determine curvature in the rail system, and control the application of the liquid composition to the rail surface. A rail-width detection system may also be employed that can detect changes in the distance between the rails due to deflection of the outside rail within a curve. Furthermore, a gyroscopic device may be used to determine topological information of the railway system and provide this information to the device for controlling the application of the liquid composition to the rail surface.

[0090] Alternatively, the rail car delivery system of the present invention may also be operatively linked to a control system within a locomotive, where the electrical components, or the controller system, in the rail car receives instructions from a locomotive control circuit. These instructions are then used to regulate the delivery system of the rail car. The locomotive control system may be used to 1) process changes in topological information in the rail system, for example using a GPS or other rail topological sensing systems as described herein; 2) control the dispensing system as required using information obtained from evaluation of rail topological data, for example but not limited to, orientation of the rail car, speed of the rail car, curve sensing, sensing severity of a curve, or changes in elevation, to regulate composition delivery to one or both of the tracks, to the top or gauge-face of the rail,

or both; 3) monitoring pressure, temperature, valve status, pump status and other circulation parameters within the reservoir, pipe system, supply lines, circulation pump, metering pump(s), filter(s), and nozzle assemblies; 4) controlling the heating system as required within the reservoir, pipe system, supply lines, circulation pump, metering pump(s), filter(s), and nozzle assemblies; 5) regulating the metering pump output with respect to rail car speed, to ensure a consistent amount of the fluid composition is applied to the railhead; 6) controlling dispensation of the fluid composition for example if a low tank level switch is activated, shuts down fluid dispensation if high pressure is detected in the dispensing system, switches off the fluid dispensation if a specific drop in brake pipe pressure is determined, or if atomizing air pressure is lost; 7) shutting of the delivery system below a threshold rail car speed; 8) determining the orientation of the rail car within respect to the train consist; and 9) a combination of the above.

[0091] Additionally, the rail car delivery system of the present invention may also be operatively linked to a control system that is monitored and accessed remotely, where the electrical components, or the controller system, in the rail car send and receive instructions from a system separate from the rail car or train consist. In this example, the remote system may access and monitor system data, send operational instructions to the delivery system regulate the system, or both. The remotely control system may be used to:

- record changes in topological information in the rail system, as received from for example a GPS or other rail topological sensing systems as described herein located on the rail car;

- monitor, control, or both monitor and control the dispensing system as required using information obtained from evaluation of rail topological data, for example but not limited to, orientation of the rail car, speed of the rail car, sensing severity of a curve, curve sensing, changes in elevation, to regulate composition delivery to one or both of the tracks, to the top or gauge-face of the rail, or both;

- monitoring pressure, temperature, valve status, pump status and other circulation parameters within the reservoir, pipe system, supply lines, circulation pump, metering pump(s), filter(s), and nozzle assemblies;

- controlling the heating system as required within the reservoir, pipe system, supply lines, circulation pump, metering pump(s), filter(s), and nozzle assemblies;

- monitor, regulate, or both monitor and regulate the metering pump output with respect to rail car speed, to ensure a consistent amount of the fluid composition is applied to the railhead;

- monitor, control, or both monitor and control dispensation of the fluid composition for example if a low tank level switch is activated, shuts down fluid dispensation if high pressure is detected in the dispensing system, switches off the fluid dispensation if a specific drop in brake pipe pressure is determined, or if atomizing air pressure is lost;

- shutting of the delivery system below a threshold rail car speed, or within certain urban areas;

- determining the orientation of the rail car within respect to the train consist; and

- a combination of the above.

[0092] The present invention has been described with regard to one or more embodiments. However, it will be apparent to persons skilled in the art that a number of variations and modifications can be made without departing from the scope of the invention as defined in the claims.